

A PRELIMINARY REPORT ON THE PARASITIC
ENEMIES OF THE CITRICOLA SCALE

[*Coccus pseudomagnoliarum* (Kuwana)]
WITH DESCRIPTIONS OF TWO
NEW CHALCICOID PARASITES.

By

HAROLD COMPERE

University of California, Citrus Experiment Station.

ABSTRACT

The so-called citricola scale has been found by Clausen to be synonymous with *Coccus pseudomagnoliarum* (Kuwana). In California this scale is preyed upon by at least four species of primary parasites, which are the same species attacking *Coccus hesperidum* Linn. The latter scale is held in check almost entirely by these parasites and it is the opinion of the writer that their lack of effectiveness on the citricola scale is due to the fact that *pseudomagnoliarum* has but one generation per year while *hesperidum* has several. Several *hyperparasites* are found in connection with the soft brown scale. Biological notes and descriptions of two new parasites are given.

According to Mr. C. P. Clausen, the citricola scale was first described by Dr. S. I. Kuwana as *Lecanium pseudomagnoliarum* from specimens taken at Oji near Tokyo, Japan.² In the same year, 1914, supposedly the same species was described by Mr. Roy Compbell as a new scale from California and given the name *Coccus citricola*. Clausen has placed the name *C. citricola* in synonymy and the name now stands as *Coccus pseudomagnoliarum* (Kuwana). Professor H. J. Quayle states that in California this pest was first noticed in Claremont in 1909, and at about the same time near Riverside and in certain sections of San Bernardino county. In recent years the citricola scale has greatly extended its range, and has become very abundant, so that it now ranks as one of the major pests of the citrus in the interior districts of southern California, and in certain citrus areas of central California it takes first place.

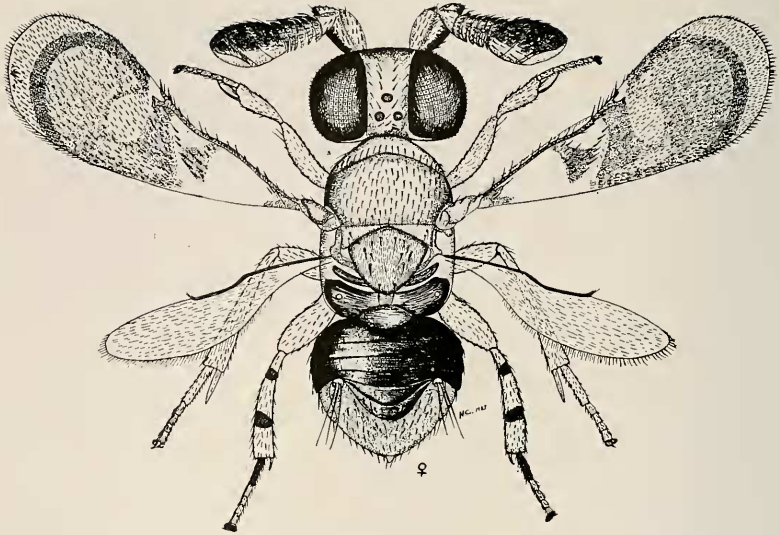
In California the citricola scale is preyed upon by at least four species of internal parasites. According to previous records and our rearings there are *Aphycus luteolus* Timb., *Microterys flavus* (How.), *Coccophagus lecanii* (Fitch), and *Coccophagus lunulatus* How.

One is immediately struck by the fact that this aggregation of parasites is the same complement which in California effectively controls the soft brown scale *Coccus hesperidum* Linn. The soft brown scale is an insect from which the citrus grower of today has little to fear, yet in the early days of citrus culture it is said to have been

¹This paper is a result of work carried on while the writer was in the employ of the California State Department of Agriculture.

²The Citricola Scale in Japan, and its Synonymy, C. P. Clausen, Journal of Economic Entomology, Vol. 16, No. 2, p. 225, April 1923.

Figure 1.

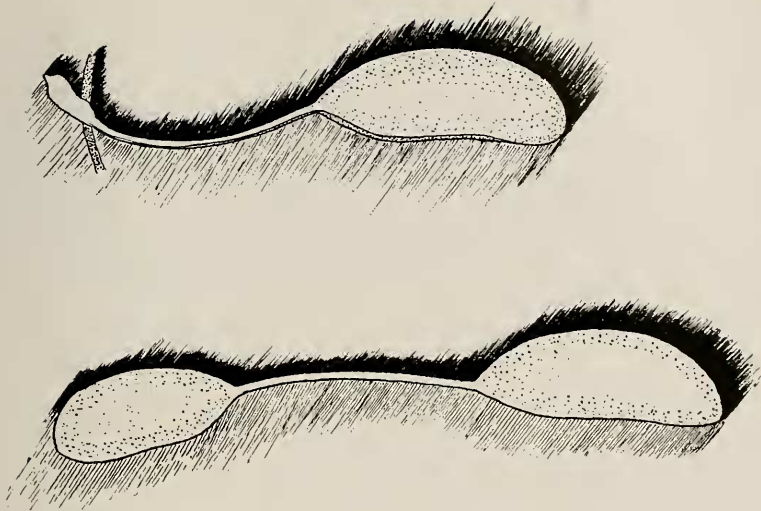


Anicetus annulatus Timb. Female.

one of the worst pests and to have vied in destructiveness with the black scale, *Saissetia oleae* (Bern.) The question immediately arises, if the soft brown scale is held in check entirely through the influence of parasites, why is not the citricola, a cogeneric host favored by the same parasites also controlled? If what we have learned regarding the seasonal history of the black scale in its relation to that of the parasites can be used as a basis for comparison one explanation may be offered. So far as we know, the parasites of the soft brown and the citricola scales, like those of the black scale, cannot long survive a dearth of suitable-sized hosts. The scales may be present in enormous numbers, but if they are of a size rendering them invulnerable to attack they cannot be utilized as food by the parasites. At certain seasons of the year they are immune to certain of their enemies because of their small size, not containing enough substance to nourish the parasitic larvae to maturity. Later their large size and toughened derm makes them unattractive to some of their parasites. To our knowledge, none of the parasites are capable of attacking the scales in all of their different life stages, each parasite showing a marked predilection for certain sizes.

In southern California with its even, temperate climate, the parasites are active throughout the entire year if provided with the proper host material. The only difference is, that in the winter months their growth is slower, and the adults are not so active, but at no season is their activity entirely suspended. If the parasites have the ability to long survive a dearth of suitable-sized hosts, this fact has not been recognized. With some species it appears, however, that such is the case, for at certain seasons some parasites suddenly appear in considerable numbers just at the time when their hosts become vulnerable. In the case of the species under consideration, a dominating number of parasites accumulate only as the result of uninterrupted multiplication. In the absence of suitable-sized scales in which

Figure 2.



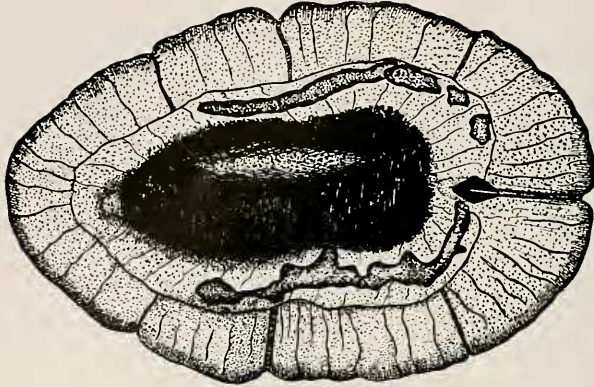
Newly laid egg with tip of stalk projecting through integument of host and the egg before oviposition.

to propagate they perish after a month or so, without having laid their quota of eggs.

Bearing in mind the limitations of the parasites, the seasonal life history of their hosts must be considered. The soft brown scale produces three or four annual generations, the hatch of young being very uneven and the different broods overlapping, so that the various stages of the pest are always present at any season of the year. When working on an infestation of this sort, the parasites always find some of the scales of a proper size to nourish their larvae, and a continuous increase of parasites usually results. In the case of the soft brown scale, the parasites when once given a start propagate continuously, finally reaching dominating numbers and producing satisfactory natural control. In comparison, the citricola scale matures only one annual generation, and the development of the brood is more or less uniform, so that the scales are all parents at the same time, and the young grow up together.

When working on an infestation of citricola scales, the parasites able to prey only upon individuals of about a certain size, are placed under a handicap, for the nature of the food supply permits only a limited period for propagation each year. When the scales become vulnerable the parasites commence to increase, but before they accumulate in sufficient numbers to control the pest, the scales develop an immunity by reason of their increased size, or by passing into the younger stages, as the case may be. At times the parasites of the citricola scale become rather abundant, but not soon enough to result in satisfactory control. What has just been stated applies to the conditions and parasites which exist in California. In Japan the conditions may be different, as the citricola scale is comparatively scarce, supposedly due to the influence of parasites. A careful study of the seasonal history of the citricola scale in Japan in its relation to that of its parasites would probably result in showing

Figure 3.



Characteristic appearance of a palm scale *Eucalymnatus tessellatus* (Signoret) when inhabited by the pupa of *Anicetus annulatus* Timb.

just what to expect from the establishment of the Japanese parasites in the California fauna.

In 1913 a preliminary study of the California parasites of *Coccus hesperidum* was made by Mr. P. H. Timberlake, who reared them on the soft brown scale.* The life history of these parasites when attacking the citricola scale is supposedly the same as when attacking the soft brown scale. *Aphycus luteolus* Timb., mentioned by Timberlake under the name *Aphycus* sp. near *flavus* How., holds first place as an enemy of the citricola scale in California. *Coccophagus lecanii* (Fitch) is probably entitled to second place, followed by *Coccophagus lunulatus* (How.) and *Microterys flavus* (How.). A fifth species *Aphycus alberti* (How.) mentioned by Timberlake as *Aphycus* n. sp. in his paper and said to be extremely rare, has recently been reared in considerable numbers from the soft brown scale in Pasadena. It seems likely that this species will be found working on the citricola scale also.

There are several hyperparasites in the local fauna which will probably prove detrimental to certain of the parasites of the citricola scale if they ever become very abundant. Timberlake records six hyperparasites, four of them obligatory internal parasites of *Microterys* and *Aphycus*. The other species, one determined as *Perissopteris javensis* How. and the other *Pachyneuron* sp., were reared from the soft brown scale but their host was not determined. Mention is also made of an *Anicetus* sp. which was taken at Sacramento. According to Mr. Timberlake it is the parasite mentioned as *Anicetus annulatus* Timb. in this paper. In addition to Timberlake's record, *Tetrastichus blepyri* Ash. can be listed as one more species actually reared from the soft brown scale. All of these hyperparasites, and probably many more, will undoubtedly attack their hosts when inhabiting the citricola scale as well as they do when they locate them in the soft brown scale. Some of the hyperparasites mentioned by Timberlake under their generic names have since been described, and

*Preliminary Report on the Parasites of *Coccus hesperidum* in California. P. H. Timberlake. Journal of Economic Entomology, Vol. 6, No. 3, June, 1913.

Figure 4.



Aphycus orientalis n. sp. Female.

a new genus has been erected for one of them. The list of hyperparasites brought up to date is as follows: *Quaylea whittieri* (Gir.), *Eusemion californicum* Comp., *Eusemion longipenne* Ash., *Cheiloneurus inimicus* Comp., *Tetrastichus blepyri* Ash., *Perissopterus javensis* How., *Pachyneuron* sp.

For the past two years, the Bureau of Pest Control of the California State Department of Agriculture has been attempting to introduce into California additional natural enemies of the citricola scale. With this idea in view, a request was made that Mr. C. P. Clausen, of the Bureau of Entomology, United States Department of Agriculture, who is stationed at Yokohama, Japan, be on the lookout for any natural enemies of the citricola scale which might occur in that country. As a result of this request, Mr. Clausen has made several shipments of parasitized scale material to California. From this material four different species of primary parasites have been reared, namely, *Coccophagus yoshidae* Nakayama, *Anicetus annulatus* Timb., and the two species described as new in this paper, *Aphycus orientalis* n. sp., and *Coccophagus japonicus* n. sp.

ANICETUS ANNULATUS TIMB.

Mr. Timberlake has informed me that *Anicetus annulatus* is the species referred to in his paper on the parasites of *Coccus hesperidum* in California (loc. cit.). In a later paper Timberlake described the

species as new, and supplemented the description with the statement that an examination of the host remains indicated that this species is unquestionably a primary parasite.* The description was made from specimens reared from the tessellated palm scale, *Eucalymnatus tessellatus* Sig.

The first specimens of *Anicetus*, obtained by me issued from *Coccus hesperidum* infesting a small *Aralia* plant. This plant was taken from the Taiyo Maru, a Japanese steamer plying between the Orient and San Francisco. The plant, which was a decorative fixture of the boat, was observed by a horticultural quarantine officer who noted that the scales which infested it were parasitized. At the Whittier laboratory, where the plant was sent, ten females and several male *Anicetus* issued. These parasites were carried through three generations at the laboratory, but with each generation there was an increase in males, while the females decreased, despite the fact that they are given an opportunity to mate. This strain finally perished when only males issued. At a later date a few males and females were reared from *Coccus hesperidum* and *Coccus pseudo-magnoliarum*, received from C. P. Clausen, Yokohama, Japan. A few pairs were liberated on soft brown and palm scales on plants at the Huntington Estate, San Marino, California.

A few observations were noted when handling this parasite in the laboratory. Although very meager, it seems worth while to publish them, as our knowledge of coccid parasites accumulates so slowly.

OVIPOSITION

A few palm scales, *Eucalymnatus tessellatus*, were placed in a vial with a female *Anicetus*. The parasite made the usual preliminary examination by palpating the scales with her antennae. During the inspection the antennae were swayed from side to side, sweeping the victim. At last, after making at least a dozen preliminary inspections, and exploratory insertions with her ovipositor, she was seen to deposit an egg. The victim was a small waxy semi-transparent individual. When about to oviposit, the parasite stands over her victim and extrudes the ovipositor, which easily penetrates the derm. In all cases this female selected the smaller stages of the scale. The time which elapsed from the insertion of the ovipositor to withdrawal was about one minute.

THE EGG

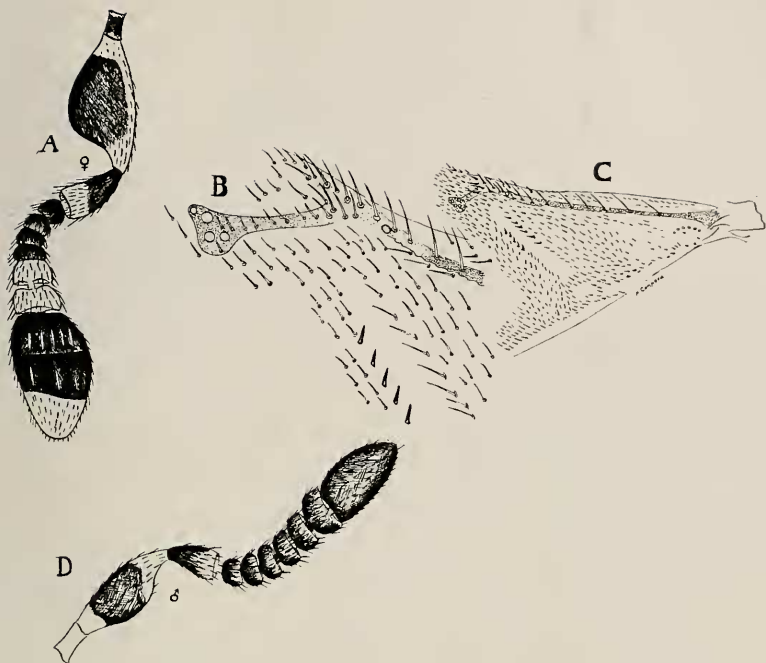
The ovarian eggs are double-bodied, consisting of two bulbous enlargements connected by a long slender neck or stalk, and are quite similar to the ovarian eggs of other Encyrtids such as *Microterys*, *Aphycus*, *Blastotrix*, etc. After deposition the newly laid eggs are located in the mid region of the scale, each suspended by a long stalk the tip of which protrudes through the derm. When the egg hatches the larva probably utilizes this stalk as an air line. The body of the egg is elongate oval, in lateral view the dorsal side is slightly convex and the under side slightly concave. They measure .15 mm. in length by .055 mm. in width. The suspending stalk is slightly longer than the bulb.

THE LARVAL AND PUPAL STAGES

The larval stages were not observed further than that they brought about a blackening of the hypodermal tissue in the mid dorsal

*Observations on the Source of Hawaiian Encyrtidae. P. H. Timberlake, Proceedings of the Hawaiian Entomological Society, Vol. 4, No. 1, pp. 227-231, June, 1919.

Figure 5.



Aphycus orientalis n. sp. Female. A—Antenna; B—Stigmal vein of forewing; C—Basal portion of forewing, male; D—Antenna

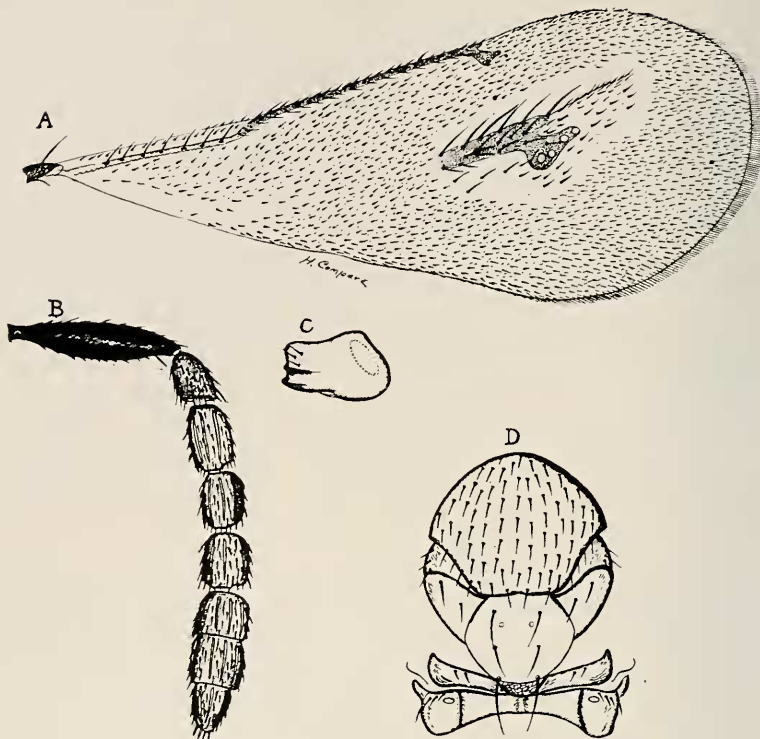
region of their hosts. This is a characteristic of *Coccophagus lecanii* and the new species described in this paper. No observations were made on the pupae. They are easily located lying face downward under the black-pigmented areas. The value of this parasite as an enemy of the citricola scale is doubtful. It has never been taken in California, except on one occasion by Timberlake, and it was the least abundant of the parasites inhabiting the citricola and soft brown scales received in the shipments from Japan.

COCCOPHAGUS YOSHIDAE NAKAYAMA*

This is a large black species with the legs partly marked with yellowish brown. It was originally described from specimens reared from *Coccus hesperidum* taken in the vicinity of Shizuoka, Japan. Several adults issued from citricola and soft brown scales received from Japan, all being of the female sex. These did not reproduce at the laboratory, although given an opportunity to work under what were supposedly ideal conditions. One female was observed in the act of oviposition; she selected a "rubber-sized" black scale in preference to some soft brown scales which were near. The method of procedure was similar to that of the other species of *Coccophagus* which have been studied. An examination of the host remains received from Japan indicate that this species is a primary parasite.

*Specimens determined by A. B. Gahan and P. H. Timberlake.

Figure 6.



Coccophagus japonicus n. sp. Female. A—Forewing; B—Antenna; C—Mandible; D—Thorax.

APHYCUS ORIENTALIS N. SP.

I am indebted to Mr. P. H. Timberlake for determining the species herein described as new. In a letter under date of October 3, 1922, he also states that this species can be separated from a somewhat similar undescribed species from China by the scutellum, which in this species is as wide as long by actual measurement, while in the undescribed Chinese specimen the scutellum is wider than long. In Timberlake's key** to the species of *Aphycus* the female of this form runs to *californicus* How. Timberlake has also verbally informed me that *californicus* How. as well as *oregonensis* How. are synonyms of *pulvinariae* How. The female of this species, although quite similar to *pulvinariae* in coloration, is very distinct structurally, the antennae being proportionately wider. In *pulvinariae* the club is one-half as wide as it is long, and from one-fourth to one-third wider than the preceding funicle joint; while in this species the club is almost two-thirds as wide as long, and one-half wider than the preceding funicle joint. The club of *pulvinariae* is only as long as the last four or five funicle joints combined, while in this form it is fully as long as all the

**Revision of the Parasitic Hymenopterous Insects of the Genus *Aphycus* Mayr. with Notice of Some Related Genera. P. H. Timberlake, Proc. U. S. National Museum, pp. 588-590, May 31, 1916.

funicle joints combined. Also, in this species the scape is wider, it being fully one-half as wide as long, and as wide as the club. In comparison the scape of *pulvinariae* tends to be less than one-half as wide as long, but as wide as the club, which is more slender. The male form runs best to *oregonensis*, from which it greatly differs in both structure and coloration.

Female

Frontovertex very slightly more than twice as long as wide; ocelli arranged in an acute-angled triangle, the posterior pair about one-half their own diameter from the eye margins, and about one and one-half times their diameter from the occipital margin, the median ocellus placed in the center of the frontovertex; antennal scape expanded below, widest just beyond the middle, one-half as wide as long, as wide as the club; pedicel as long as the first three funicle joints combined, measured across greatest thickness as wide as the fourth funicle joint; first four funicle joints of nearly equal length and all gradually increasing in width distally so that the fourth is almost one-third wider than the first, the fifth longer than the preceding and about one-fourth wider, the sixth longer and wider than the fifth and twice as wide as the first; club broadly ovate, more than one-half wider than the preceding funicle joint, as long as all the funicle joints combined (fig. 2a). Wings uniformly ciliated; the oblique hairless streak interrupted below, the cut-off portion separated from the basal hairless streak by about two rows of irregular cilia (fig. 2b, c).

Coloration—Front, vertex and mesonotum orange yellow with slight infusion of brownish; face and cheeks paler yellow merging to pallid; the latter with blackish-brown blotch of variable degree extending from the base of the cheeks upward and more or less merging with the dark coloration of the occiput, tegulae, underparts and collar of the pronotum sordid white, except as follows: tegulate with a brown spot on the posterior margins, collar of pronotum with a blackish-brown dot on either corner, and the venter of the abdomen dusky; occiput broadly across the center, concealed part of the pronotum, the metanotum, propodeum, and dorsum of the abdomen blackish, the latter fading to soiled white on the sides behind the vibrissae. Antennal scape shining black, with the base, apex and a narrow line on the dorsal margin whitish; base of pericel black, the apex whitish; first four funicle joints, and first two joints of the club blackish brown, last two funicle joints and apical joint of the club brownish yellow. Legs in ground color similar to the whitish underparts; middle tibia, at either extremity, slightly tipped with brownish black, a more or less interrupted annulus of the same color on the upper third, and another less well defined but of greater extent on the lower third; the corresponding coloration of the fore and hind tibia faint, sometimes obsolete on the forelegs; last tarsal joints tipped with dusky.

Male

Antennal scape less than one-half as wide as it is long, as wide as the club which is considerably narrower than that of the female; the first four funicle joints subequal in length, the fifth almost one-half longer than the fourth, the sixth one-fourth longer than the fifth, all gradually increasing in width so that the sixth is twice as wide as the first, and about one-fourth wider than the preceding; club elongate, hardly wider than preceding funicle joint, rather pointed at apex, about as long as the last four funicle joints taken together. (fig. 2d). Length 0.7 mm. to 0.9 mm.

Coloration—Vertex, occiput broadly across the upper half, dorsum of the thorax and abdomen black; frons orange yellow; face,

cheeks and inferior half of the occiput chrome yellow to pallid; oral margins framed in dusky cheeks with a black blotch extending from near oval margin upward behind eyes merging with dark coloration of vertex and occiput; pronotum yellowish on sides with a black blotch near either corner; mesoscutum, propodeum and lateral sides of the abdomen behind the vibrissae brownish orange yellow; tegulae yellow with a black blotch on the outer posterior corners. Scape of antennae somewhat like that of female; base of pedicel black, apical half yellow; funicle and club blackish brown. Legs similar to those of female excepting the dark coloration, which is not so well defined.

Described from ten females and five males (type, allotype, and paratypes) found in the debris of shipping boxes, received June 5, 1922, from Mr. C. P. Clausen of Yokohamo, Japan.

Biological Note

Specimens obtained from *Coccus pseudomagnoliarum* (Kuwana) and *C. hesperidum* (Linn.) as noted above. An inspection of the host remains resulted in the finding of two scales containing remnants of the parasites, and in one cell a well preserved adult clearly determinable. The old shells exhibited a honeycombed interior like that of a mature black scale (*Saissetia oleae*) when inhabited by several *Aphycus lounsburyi*. The scales were large individuals, which in life probably contained an abundance of ovarian eggs at the time of attack. The interiors were partitioned off by membranous walls forming individual pupal cells. In the pupal chambers thus formed the castings were found, and in one case an adult which had failed to issue. The other parasites had emerged through a number of exit holes which perforated the dorsum. One of the shells exhibited evidence of secondary parasitism, the pupal cases of some black species occupying the cells formed by the *Aphycus* larvae. However, this may have been only accidental parasitism, the usurper having been a *Coccophagus* of essentially primary habits. If speculation may be permitted on the basis of this evidence, it seems the mode of development *Aphycus orientalis* must follow very closely that of its congener *Aphycus lounsburyi* Howard, thus assuring strict primary parasitism.

COCCOPHAGUS JAPONICUS N. SP.*

This form is briefly characterized for the purpose of recording its introduction into California from Japan and to establish its place of origin should it later be recovered from this state. It is with hesitancy that specific rank is accorded this form as in all structural characters known to me it resembles *C. lecanii* (Fitch), it being separated merely on the basis of the difference in coloration of the legs. *C. lecanii* is subject to considerable variation in color and a large series from different parts of the world may reveal intergradations which will necessitate synonymizing this species or at least reducing it to a geographical variant. In addition to the twenty-five museum specimens from which the characterization has been drawn more than four-hundred living adults were handled, all of these being separable at a glance from the specimens of *lecanii* which have so far been taken from California. In coloration this form resembles *C. lunulatus* How. but is easily distinguished by the vestiture of the scutellum, the latter having a number of scattered hairs, while in this form the scutellum is clothed with only three pairs of strong bristles.

*In a letter under date of July 18, 1922, Mr. P. H. Timberlake stated that apparently this is a new species.

Female

Posterior two-thirds of the scutellum yellowish, the remainder of body blackish; antennal scape blackish, the funicle and club fuscous brown; all coxal joints with some blackish, sometimes entirely black; trochanters pallid; hind femora blackish, the extremities yellowish white; apical tarsal joints dusky; remainder of legs usually entirely yellowish white; in a few specimens the femora and tibiae of the forelegs are in part slightly fuscous, the suffusion being more pronounced on the femora.

Holotype and two paratypes to be deposited in the U. S. National Museum, also, a series of three paratypes to be deposited in the Museum of the California Academy of Science in San Francisco, California.

Described from 25 females (holotype and paratypes) reared from *Coccus pseudomagnoliarum* (Kuwana) and from specimens found dead in the debris of shipping boxes, received June 2, 1923, from C. P. Clausen, who presumably, collected the material in the vicinity of Yokohama, Japan. Specimens of this species were obtained from an earlier shipment made by Clausen but no specimens retained.

In the larval stages and in the mode of development this species seems to resemble *C. lecanii* very closely. The derm of the parasitised host takes on the characteristic black pigmented appearance. Some four hundred adults were colonized in several districts of southern California as a result of Clausen's shipment. Whether or not they have become established is not known at this writing.

